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TECHNICAL NOTE NO. 1617

AIRCRAFT DAMAGE AND CASUALTIES FROM GROUND FIRE IN SOUTH VIETNAM OPERATIONS (U)

by

Horace C. Smith
Roland G. Bernier

July 1966

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AIRCRAFT DAMAGE AND CASUALTIES FROM GROUND FIRE IN SOUTH VIETNAM OPERATIONS (U)

Horace C. Smith
Roland G. Bernier

Weapon Systems Laboratory

RDT&E Project No. 1P121401A150

ABERDEEN PROVING GROUND, MARYLAND

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(UNCLASSIFIED) FOREWORD

The results of this study were originally presented at the Seventeenth Military Operations Symposium (MORS) in May 1966 and will be published as part of the proceedings. Since the MORS presentation, serious doubts have arisen concerning the cause of the CH54 crash involving five injury type fatalities. The cause of the crash may not have been due to enemy ground fire.

This report is the forerunner of a more comprehensive analysis concerning U. S. Army aviation casualties in South Vietnam from 1962 through March 1966. It is being issued in its present form because of urgent need, and to insure a wider distribution of the information.

BALLISTIC RESEARCH LABORATORIES

TECHNICAL NOTE NO. 1617

HCSmith/RGBernier/sjw
Aberdeen Proving Ground, Md.
July 1966

AIRCRAFT DAMAGE AND CASUALTIES FROM GROUND FIRE IN SOUTH VIETNAM OPERATIONS (U)

(UNCLASSIFIED) ABSTRACT

This report analyzes casualty data on U. S. Army personnel aboard aircraft in South Vietnam from 1962 through March 1966. Casualties are classified in three main categories: wounds (caused by projectiles and aircraft debris); injuries (resulting from crashes, forced landings, etc. caused by ground fire hits on the aircraft); and others (reported casualties requiring segregation from the wounds and injuries). A serious attempt was made to exclude casualties resulting from accidents not involving ground fire hits.

Data indicate that injury type fatalities occur more frequently than wound type fatalities.

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(UNCLASSIFIED) TABLE OF CONTENTS

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(UNCLASSIFIED) INTRODUCTION AND OBJECTIVE

An outstanding difference between the present conflict in Vietnam and all the previous wars of history is the use of the helicopter. Its full impact has not yet been completely recognized; its full exploitation in some roles remains controversial. Like all other weapon systems, serious changes in existing helicopters and proposed new machines must be justified by rigorous cost-effectiveness studies. Among other factors, survivability must be quantified and considered in the evaluation balance along with many other desirable characteristics such as performance, maintainability, etc. Decisions and compromises among the various desirable characteristics become more critical to the helicopter than perhaps to any other type of system for one main reason - weight. Weight is perhaps the overriding criterion to justify anything that goes on a helicopter - even for increased survivability. It therefore becomes more important and more critical than ever to strive for more data, more objectivity in data and more realism in its application.

The Ballistic Research Laboratories (BRL) have studied aircraft vulnerability for many years. Test data have been collected and mathematical predictive techniques have been developed which meet the criteria for objectivity perhaps even better than actual combat data. Unfortunately, the application of these developments requires assumptions to approach realism, and for this aspect there is no substitute for actual combat data. The analysis of the Vietnam data has provided many other side benefits in solving immediate survivability problems, but the main objective of these studies by the BRL is to provide realism for the predictive studies.

(UNCLASSIFIED) THE COMBAT DATA AND ITS ANALYSIS

Originally, the prime source of combat data for these studies was the Ground Fire Damage Report (since evolved to the Joint Services Incident and Damage Report) from Vietnam, but the limitations of any single source of such data were soon realized. Among the other sources now used are

the following:

1. TWX - A daily report of one line pertaining to each hit or incident from 2nd Air Division, Tan Son Nhut.

2. Casualty reports from the Adjutant General's Office.

3. Accident Summary Reports and other publications from USABAAR, Fort Rucker.

4. Operations reports from DA staff office.

5. "Tech Rep" reports from various aircraft manufacturers servicing aircraft in Vietnam.

Each of the sources has provided key pieces of data; each has its limitations.

Combat data, like most other types of statistics on human operations, are by nature complex compared to experimental laboratory and field data. Strict control is humanly impossible, hence the processing requires considerable culling; herein lies a serious danger of defeating the main purpose of its collection and analysis.

To conserve the realism of the data, the authors attempted to code every possible item of information. A few years ago this philosophy of analysis would have produced an unmanageable monstrosity. The BRL high-speed computer, BRLESC, with its large memory capacity makes this type of analysis feasible. Comprehensive information recall programs are designed to accept all the data and produce hundreds of correlation tables of two or three parameters at a time. For instance, the date of the aircraft hit, number of hits, the components hit, altitude, speed, range, type of projectile, etc., and the results of each hit are coded, and tables are produced correlating such things as frequency of hits by month, distribution of hits on an aircraft type, number of hits versus altitude, speed or both. The analyses have been restricted, however, to only that data related to hits on aircraft (including flying personnel).

As of May 1966 two studies have been published. BRL Technical Note No. 1589 presented correlation tables with no conclusions by the authors. BRL Memorandum Report 1647 analyzed all the ground fire hits reported on UH-1 helicopters to the end of 1964. This study brought out the most important causes of crashes and forced landings. The study was an important factor in deciding on the requirements for additional protection on the armed UH-1's; the requirements are now being met. Plans to update this study on the UH-1 and to conduct similar studies on the other Army aircraft have been slow to materialize due to problems in data collection. Analysis of the casualty data has been more successful, however, and this is discussed next, as representative of the approach and the results in these studies.

(CONFIDENTIAL) U. S. ARMY AIRCRAFT COMBAT CASUALTIES

Reports of all casualties to U. S. Army personnel occurring in aircraft (including non-U. S. Army aircraft) from ground fire in Vietnam, from 1962 through March 1966, were obtained from the files of the Adjutant General's Office. The reports exclude non-U. S. Army casualties occurring on Army aircraft. Reports were included on all casualties caused directly by bullets and structural debris produced by bullet impacts and on all casualties from crashes caused by hits on vulnerable aircraft components. An attempt was made to exclude casualties from accident crashes not involving bullet hits. An attempt was also made to exclude wounds occurring to airmen while not actually on the aircraft. This source of data was complete and detailed as to type of casualty, severity, site, cause, etc. Its limitations were lack of detail on projectile type, cause of crash, and flight conditions at the time of the hit. The data are summarized in

the following Table I:

TABLE I

(CONFIDENTIAL) U. S. ARMY COMBAT CASUALTIES IN AIRCRAFT (U)
(1962 through March 1966)

Casualty Type	Superficial	Serious	Fatal	Total
Injuries	55	63	142	260
Wounds	551	276	49	876
Others	116	16	1	133
Total	722	355	192	1269

By type, the casualties are arbitrarily classified into injuries, wounds and other. The wounds are casualties from direct hits on personnel by bullets, fragments and other missiles including debris caused by perforation of the aircraft structure. The injuries are casualties due to injuries from crash (or hard landings) caused by projectile hits on vulnerable aircraft components. The "other" are miscellaneous casualties such as burns from rocket blast or hot gun barrels, wounds from ejected cases while on the aircraft; only one was fatal and little more need be said about these. The numbers of wounds and injuries, on the other hand warrant considerable analysis. By severity, the casualties are classified into fatal, serious (but non-fatal) and superficial. Superficial implies "treated and returned to duty"; serious implies "hospitalized" in Vietnam or returned to the United States; fatal includes both fatal immediately and fatal later. A very significant observation is that more fatalities occurred because of crashes than because of direct hits on personnel. This observation implies that more fatalities could be prevented by protecting vulnerable components of the aircraft than by armoring personnel. It probably also reflects the fact that during this period some of the pilots and copilots were provided with torso protection, but none of the aircraft were provided with critical component protection, which is now being provided even though there are serious objections to the added weight. The main lessons to be learned are that ground-fire hits must be accepted as part of the environment of combat helicopters, and protection must be

designed into them from the beginning to avoid weight penalties and costly retrofit programs and engineering changes at a later date.

The distribution of casualties by aircraft type is presented in the following Table II:

TABLE II

(CONFIDENTIAL) CASUALTIES BY AIRCRAFT TYPE (U)

Aircraft Type	All Casualties		Fatalities Only	
JOV1	21		3	
CV2B	22		10	
O1	44		6	
U1A	11		3	
U6A	4		1	
U10	1		1	
C123	4		2	
A1E	1		0	
Total Fixed Wing	108		26	
UH1A	4		1	
UH1B	947		121	
UH1D	67	1019	13	135
UH1E	1		0	
CH21	90		11	
CH34	3		0	
CH37	11		4	
CH47	19		8	
CH54	5		5	
OH13	14		3	
Total Rotary Wing	1161		166	
TOTAL	1269		192	

As expected more casualties occurred on rotary wing aircraft because of their larger population than on fixed wing aircraft. Of the rotary wing, more occurred on the HU-1's than on all others. Of these, from other sources of combat data, it can also be shown that most of the casualties occurred on the armed escorts rather than on the unarmed transports, in spite of the (approximate) two to one ratio in population of unarmed to armed.

The distribution of casualties by crew station is presented in the following Table III:

TABLE III

(CONFIDENTIAL) ALL CASUALTIES BY CREW STATION (U)

	Injuries	Wounds	Others	Total
Pilots and copilots	108	384	26	518
Crew Chiefs and Gunners	105	381	98	584
Observers and passengers	47	111	9	167
TOTAL	260	876	133	1269
Fatalities Only By Crew Station				
Pilots and copilots	63	22	0	85
Crew Chiefs and Gunners	54	22	1	77
Observers and passengers	25	5	0	30
TOTAL	142	49	1	192

The "Wound" category warrants considerable further examination. Table IV subdivides the wounds by location, i.e., head and neck, torso, legs, and arms. All but seven of the wound fatalities were caused by hits on the head, neck, and torso. (Two of the exceptions were exsanguination due to hits in the upper thigh and five fatalities due to "numerous wounds" where the exact anatomical locations are unkown.) This finding seems to justify the Army policy of developing torso armor for application either to aircraft seats or directly on the personnel. Head protection presents a complex problem which has not been adequately solved.

TABLE IV

(CONFIDENTIAL) WOUNDS ONLY VERSUS LOCATION (U)

Location	Fatal	Serious	Superficial	Total
Head & Neck	20	28	101	149
Torso	22	30	16	68
Leg	2	140	154	296
Arm	0	77	275	352
Numerous wounds	5	0	0	5
Unknown	0	1	5	6
TOTAL	49	276	551	876

Wound severity versus cause is presented in Table V. It is significant that all the fatal wounds were due to direct hits by projectiles, and no fatal wounds were caused by debris associated with perforation of aircraft structure. Since such debris is relatively easy to stop, with very little weight penalty introduced by the protective measures it should be possible to prevent most of the superficial wounds and some of the serious wounds in the arms, legs, head and unarmored torso. The face wounds suggest that the visors were not always worn.

TABLE V

(CONFIDENTIAL) SE' ' T' VERSUS CAUSE (WOUNDS ONLY) (U)

Cause	Fatal	Serious	Superficial	Total
Bullets	45	183	64	292
Fragment	4	11	9	24
Shrapnel	0	28	26	54
Debris Plexiglass	0	4	71	75
Debris Metal	0	47	370	417
Land Mine	0	0	4	4
Unknown	0		7	10
TOTAL	49	27	551	876

In searching for means to reduce fatalities, Army agencies such as the Army Materials Research Agency, the Natick Laboratories and their contractors have made great strides in the field of lightweight armors for both aircraft and personnel protection. Most of the Army aircraft in Vietnam have torso protection at least for the pilot and copilot against caliber 0.30 type armor-piercing bullets. New developments indicate protection against caliber 0.50 armor-piercing bullets may be possible for practically the same weight of armor. Unfortunately, armoring only the personnel will not prevent aircraft crashes. In fact, of all the documented crashes, only three were from hits on pilots, and only one of those resulted in crash casualties.

(CONFIDENTIAL) CASUALTY TRENDS

To study "trends" in casualties, U. S. Army aircraft operations curves were used as a data base (Figure 2). Data for 1962 are not available. However, from the first quarter of 1963 through the second quarter of 1965 the trend in Combat Support Sorties (CSS) increased at about a constant rate. After a slight decrease in activity during the third quarter of 1965, the number of operations increased sharply. This sharp increase in operations can be credited to the commitment of the 1st Air Cavalry Division to battle.

The curve representing Rotary Wing Aircraft Combat Support Sorties closely follows the trends of the curve for all Army aircraft and both curves can be considered as a "measure of exposure" to enemy fire.

The significance of the trends, as shown by the operations curves, becomes more meaningful when trends in wounds and injuries are studied.

In Figure 3, which shows U. S. Army casualties from wounds and injuries aboard aircraft, the "All Casualties" curve is similar in shape to the operations curves of Figure 2. Thus, as the rate of exposure is increased, a corresponding increasing casualty rate is to be expected. A curve representing "Fatalities Only" is also shown in Figure 3. This curve reflects the increased level of exposure, but shows a significantly lower rate of change. In order to explain the difference in the rates of change shown in the curves for "All Casualties" and "Fatalities Only", it is necessary to separate the casualties into "Wound" and "Injury" categories.

Figure 4 presents "Wound" type casualties only and the curve representing "All Wounds" (Fatalities, Serious and Superficial) characteristically reflects the increased level of exposure as shown in Figure 2. However, the "Wound Fatality Curve" is essentially flat and does not reflect increased aircraft activity as shown, for example, in Figure 3 (All Casualties).

The reason for this apparent contradiction is simply that the Army Personnel Armor Protection Program has proved effective. From 1962 to the present time, efforts have been directed toward improving personnel

protection for Army aviators and, to a lesser degree, other crewmembers. The success of this program can be measured by the almost constant number of "wound fatalities" in the face of ever increasing air operations and hence exposure to fire.

The same statements cannot be made concerning the subject of "Fatalities caused by Injuries" (Crashes and Hard Landings).

The "All Injuries Curve" of Figure 5 generally corresponds to the operational curves shown in Figure 2: as exposure increases, aircraft loss rate also increases. The "Injury Fatality" curve indicates that an Injury Casualty is usually a Fatality.

Aircraft critical component protection programs have not kept pace with personnel armor programs.

For each wound type fatality (49) three (142) injury type fatalities occurred. This fact suggests that the vulnerability of aircraft must be reduced in order to reduce the overall fatality rate.

In addition to the life saving benefits of such a program, a number of aircraft losses could be prevented.

(CONFIDENTIAL) AIRCRAFT "KILLS"

Vulnerability means many things other than casualties; combat damage data are also studied to understand causes of aircraft losses, forced landings and mission aborts. Since significant changes occurred in 1965, such as the entrance of United States Divisions into the conflict, some changes are anticipated in the aircraft "kill" trends. The detailed statistics of the hits through the end of 1964 have been reported in BRL Memorandum Report No. 1647 and their repetition is not warranted in view of the anticipated changes. However, the major conclusions are not expected to change very much. The largest identifiable cause of UH-1 losses was found to be fires-in-flight caused by hits on critical parts of the fuel system. Another significant cause of crashes was found to be damage to the engine compressor and fuel control. Causes could not be positively identified in a significant number of cases because it is not

always possible (nor required) to thoroughly investigate crashes in hostile action. It is strongly suspected, however, that most of the unidentifiable causes were probably the same as those which were identified.

The most frequent cause of forced landings was loss of oil from the engine system and from the transmission system. Test work on the UH-1 inidcates flight is limited to about 5 minutes after engine oil starvation and about 10 minutes after transmission oil starvation. When coupled with the fact that some force-landed aircraft have been destroyed on the ground by the VC, the significance of oil leaks becomes important.

Mission aborts resulted from a variety of causes; perhaps the highest single cause reported was "personnel casualty".

Over 2,400 hits have been reported, and at least on the UH-1 practically every component and system have been hit. The rotor blades were hit over 200 times but in only a few cases did anything more than severe vibration result.

Among other things it was found that hits are uniformly distributed; hence given a hit on the aircraft, the probability of hitting any section of the aircraft is predictable. Such a comparison is presented in Figure 1.

(CONFIDENTIAL) OPERATIONS DATA

When hit data, casualty data, and aircraft "kill" data can be matched chronologically with operational data, such as number of aircraft sorties or flying hours, estimates of risk can be made. For all U. S. Army personnel, aircraft combat casualties, the data through 31 March 1966 indicate:

1 Casualty per 1317 combat support sorties.

1 Wound type casualty per 1908 combat support sorties.

1 Injury type casualty per 6430 combat support sorties.

1 Fatality (Wound) per 34119 combat support sorties.

1 Fatality (Injury) per 11773 combat support sorties.

Such risks appear tolerable and are in fact remarkably low. However, when one considers the hundreds of thousands of combat support sorties flown over Vietnam, the risks add up to significant losses of critical resources - both men and machines. When one further considers that the materials and techniques are available to eliminate most of the causes of loss, it becomes increasingly important to positively identify all the causes.

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Mr. George Francis of the Computing Laboratory, U. S. Army Ballistic Research Laboratories, for the design of the BRLESC computer information recall program.

HORACE C. SMITH ROLAND G. BERNIER

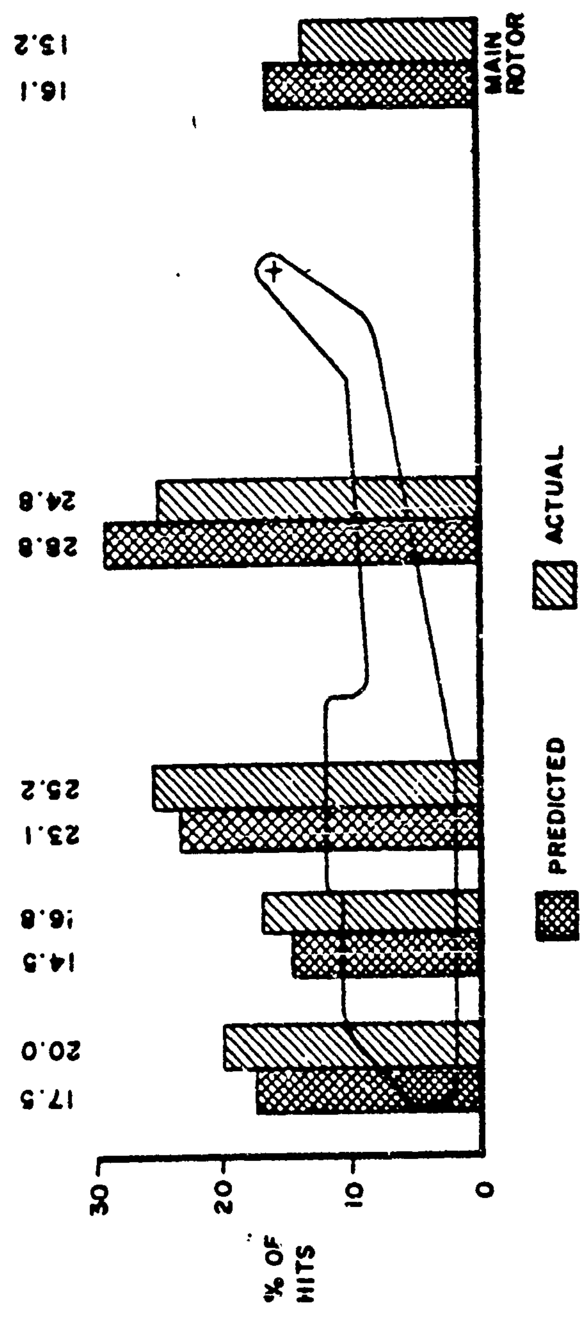


FIG. I (CONF.) PERCENT OF HITS ON MAJOR COMPARTMENTS (U)

FIG. 2 (CONF.) OPERATIONS DATA (QUARTERLY) (U)

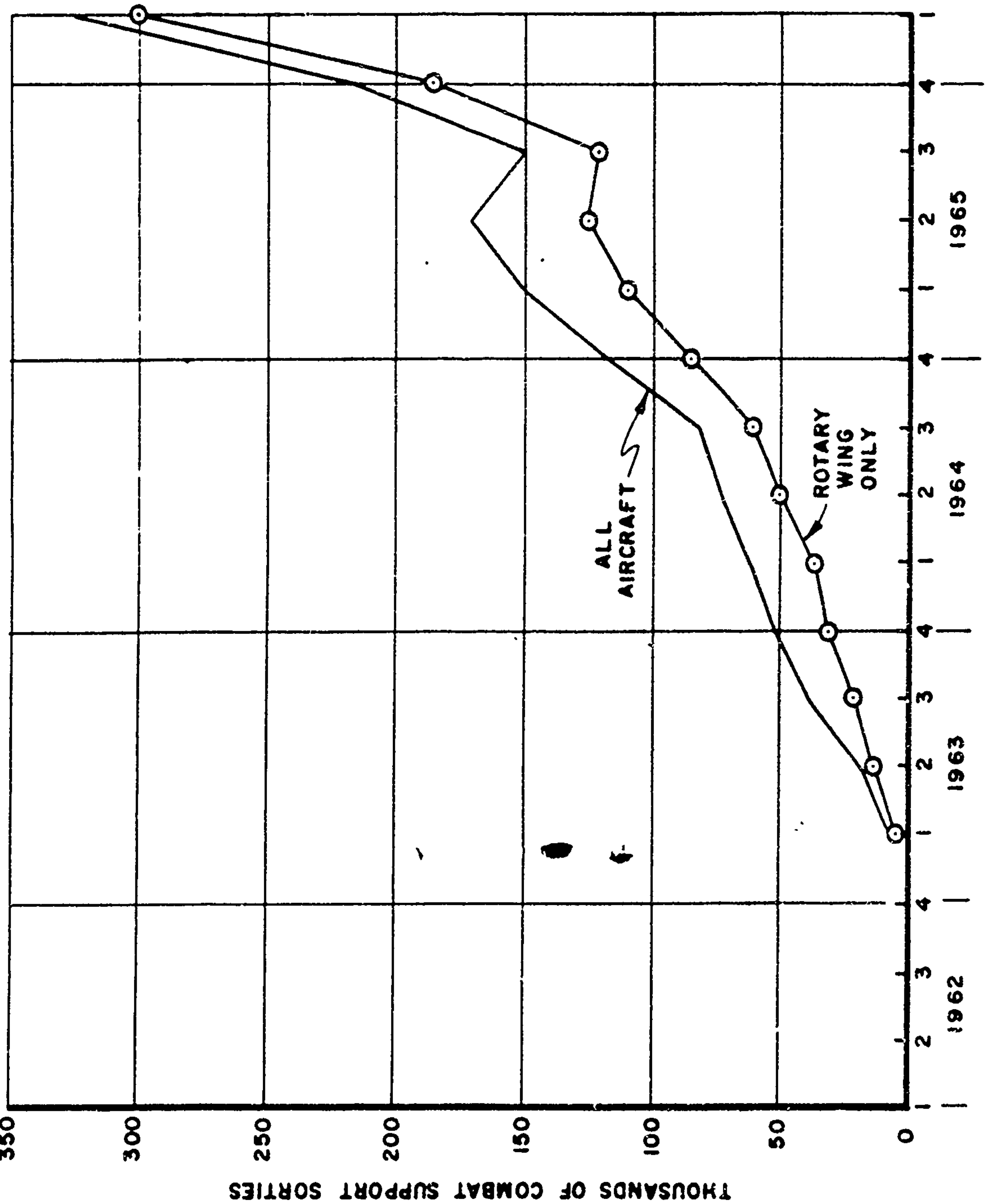


FIG. 3 U.S. ARMY CASUALTIES
ABOARD AIRCRAFT IN SOUTH VIETNAM
ALL CASUALTIES (QUARTERLY)

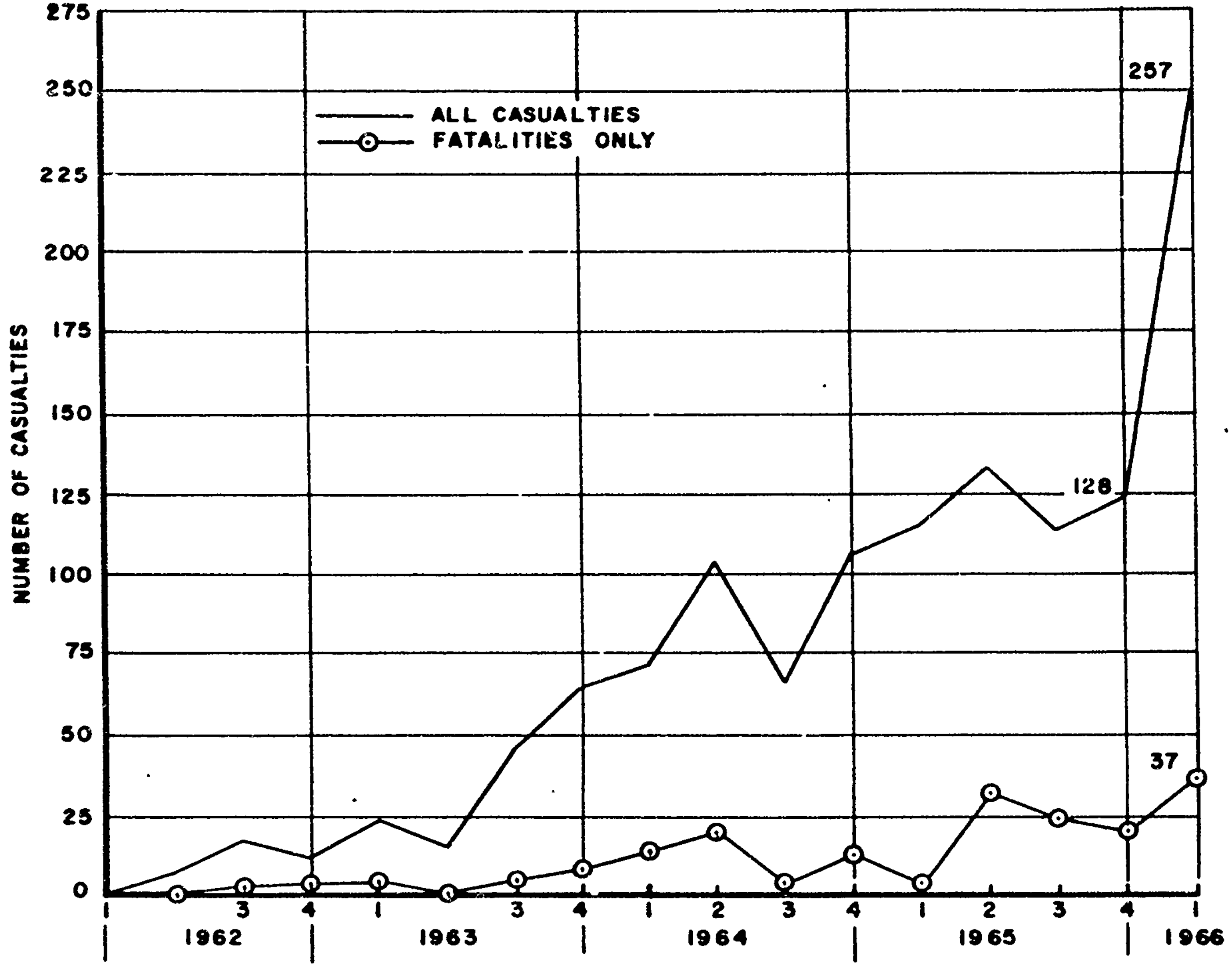


FIG. 4 U.S. ARMY CASUALTIES ABOARD AIRCRAFT IN SOUTH VIETNAM WOUNDS ONLY (QUARTERLY)

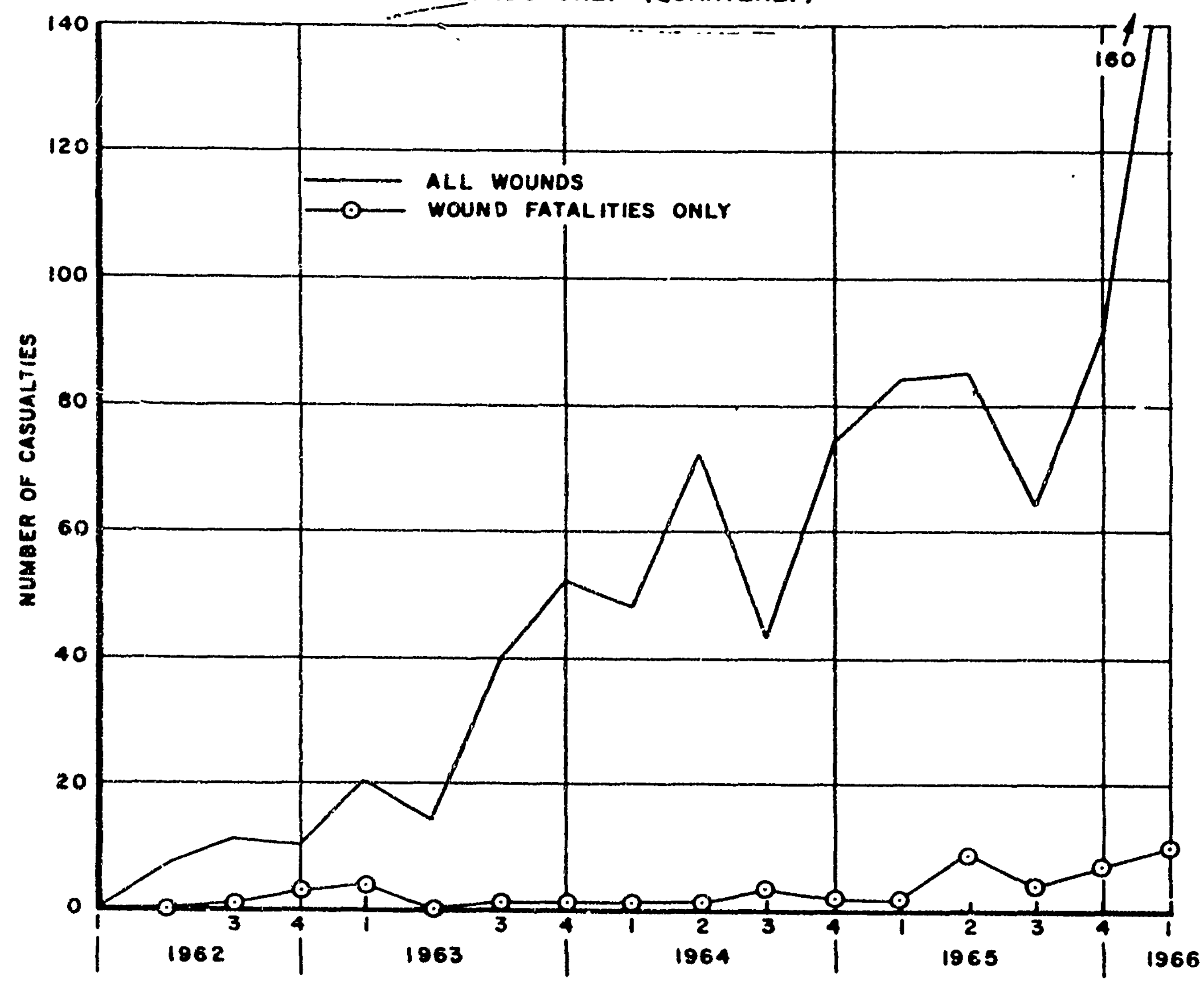


FIG. 5 U.S. ARMY CASUALTIES
ABOARD AIRCRAFT IN SOUTH VIETNAM
INJURIES ONLY (QUARTERLY)

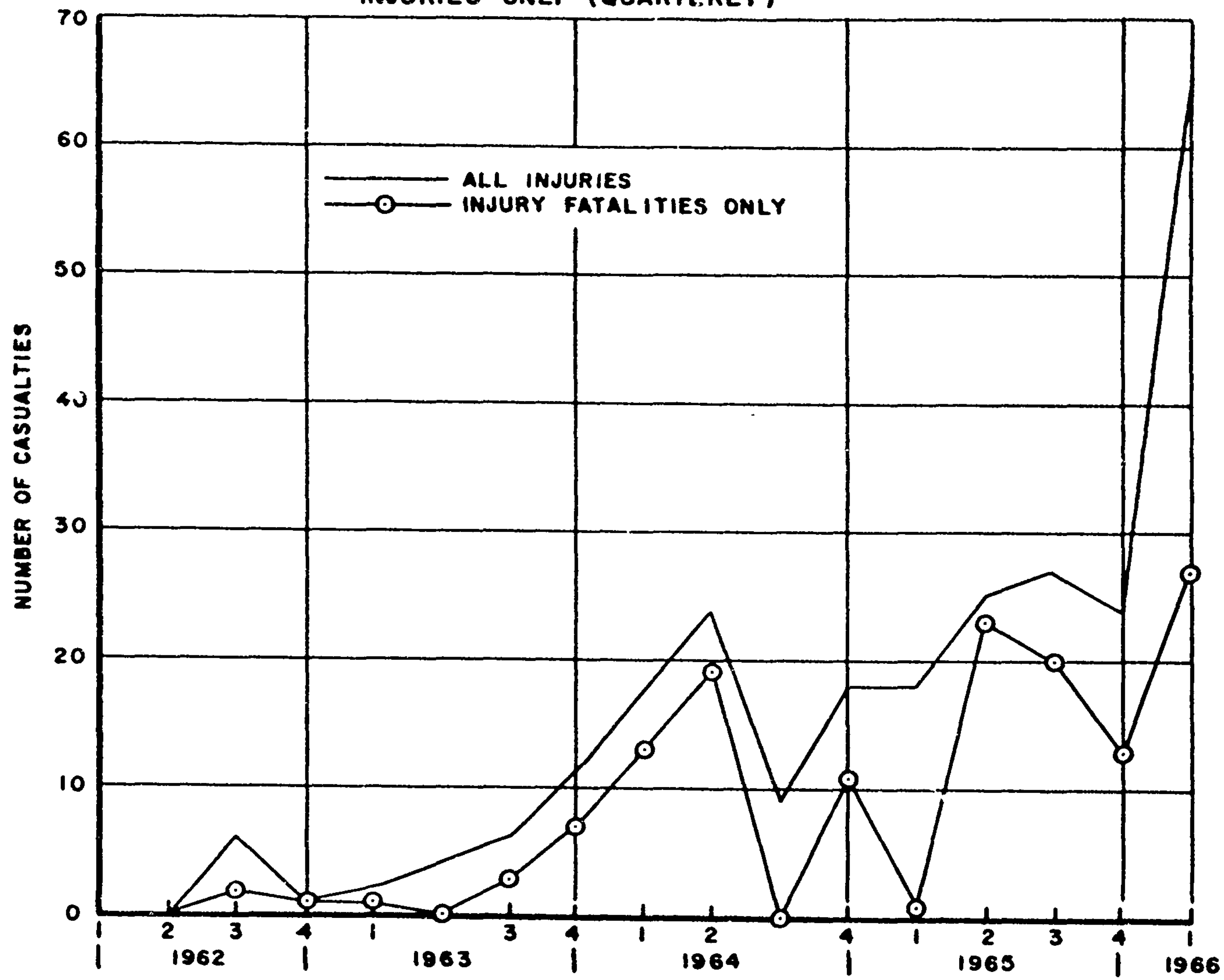
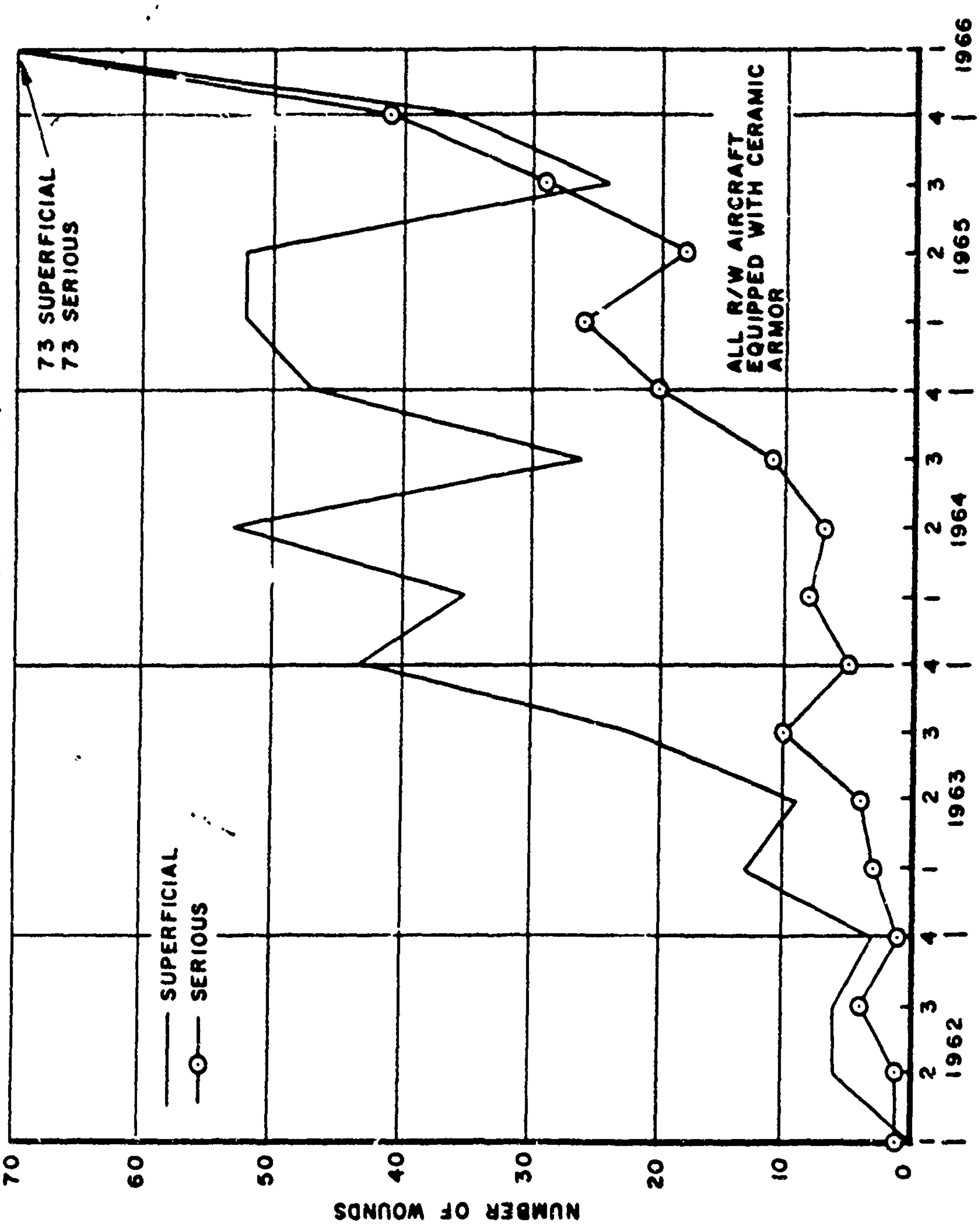


FIG. 6 U.S. ARMY CASUALTIES
ABOARD HELICOPTERS IN SOUTH VIETNAM
WOUNDS ONLY (QUARTERLY)



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U. S. Aircraft Casualties in Vietnam Wound Locations Wound Severity by Cause Aircraft Vulnerability Operations Versus Casualties						

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